U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Pacific Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2006

Alaska Fisheries Data Series Number 2007–4

Kenai Fish and Wildlife Field Office
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Miranda P. Plumb, Ken C. Harper, and Dan G. Spencer

Abstract

The Kenai Fish and Wildlife Field Office operated a weir on the Tuluksak River, a tributary to the lower Kuskokwim River in the Yukon Delta National Wildlife Refuge, between June 30 and September 6, 2006. The resistance board weir was used to collect abundance, run timing, and biological data from returning salmon. These data supported in-season management of the commercial and subsistence fisheries in the Kuskokwim area. In 2006, 23,932 chum *Oncorhynchus keta*, 993 Chinook *O. tshawytscha*, 920 sockeye *O. nerka*, 2,093 pink *O. gorbuscha* and 2,393 coho salmon *O. kisutch* passed the Tuluksak River weir. Peak weekly passage occurred from July 16 to 22 for Chinook, chum, sockeye, and pink salmon, and from August 20 to 26 for coho salmon. Fish passage was calculated for 27 days when either partial or no escapement numbers were collected due to high water events. Escapement estimates were generated using average daily proportions of fish passing the weir on those days between 1991-1993 and 2002-2005. Based on corrections made to actual counts we estimated that 25,648 chum, 1,044 chinook, 985 sockeye, 2,448 pink, and 6,138 coho salmon escaped in 2006. Age 1.2 Chinook, 0.4 chum, and 2.1 coho were the dominant age classes. The sex ratios of chum and coho were approximately 1:1, while the Chinook salmon run was approximately 1:4 females to males.

Introduction

The Tuluksak River, located approximately 222 river kilometers (rkm) upstream from the mouth of the Kuskokwim River, Alaska, (Whitmore et al. 2005) flows through the Yukon Delta National Wildlife Refuge (Refuge) and supports spawning populations of Chinook, chum, pink, coho, and a small population of sockeye salmon. These salmon contribute to large subsistence and commercial fisheries in the lower Kuskokwim River drainage. In addition to human consumption, salmon provide food for brown bears and other carnivores, raptors and scavengers. These salmon also sustain resident fish species and salmon fry that rely heavily on the nutrient base provided by salmon carcasses (U.S. Fish and Wildlife Service 1992).

Under guidelines established in the sustainable salmon fisheries policy 5AAC.39.222, the Alaska Board of Fisheries designated Kuskokwim River chum and Chinook salmon as yield concerns. This designation was based upon the continued inability, despite specific management measures, to maintain expected yields, or have stable surplus above the stock's escapement needs for three of the past six years. Based upon this designation, the salmon fishery in the Kuskokwim River drainage has been managed under the Kuskokwim River Salmon Rebuilding Management Plan (Rebuilding Plan) for the past five years (5AAC 07.365; Ward et al. 2003; Bergstrom and Whitmore 2004). The portion of the Kuskokwim River within the boundaries of the Refuge was under both the Rebuilding Plan and the Federal Subsistence Fishery Management program.

The Alaska Department of Fish and Game (Department), the U.S. Fish and Wildlife Service (Service), and the Kuskokwim River Salmon Management Working Group (Working Group)

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work together to achieve the goals of both The Rebuilding Plan and the Federal Subsistence Fishery Management program. The Rebuilding Plan was established to provide management guidelines resulting in the sustained yield of salmon stocks large enough to meet the following goals: (1) To manage for the achievement of established escapement goals; (2) To meet the amounts necessary for subsistence; and (3) To allow for a commercial fishery on harvestable surplus after escapement and subsistence needs are projected to be met (Ward et al. 2003). In addition to the goals set by the Department, the Service, and the Working Group, the Alaska National Interest Lands Conservation Act (ANILCA) mandates that salmon populations and their habitats be conserved in their natural diversity within the Refuge.

The current array of escapement monitoring projects has a broad geographic distribution that samples a diverse collection of widely separated salmon spawning aggregates, and this provides vital insight to sustainable salmon management in the Kuskokwim Area. Recent tagging studies conducted on Chinook, sockeye, chum and coho salmon have all demonstrated differential stock-specific run timings with the general pattern of salmon stocks from upper river tributaries entering the Kuskokwim River earliest, while stocks from lower river tributaries enter progressively later (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003, 2004; Stuby 2004, 2005, 2006). The temporal distribution of these stock-specific run timings overlap; the difference between the mid-point of one stock and another of the same species can be several weeks. Concurrent with this phenomenon is the occurrence of extensive subsistence fisheries that tend to harvest more heavily from early arriving salmon, and commercial fisheries that have historically focused on early, middle or late segments of the overall salmon run (D. Molyneaux, Alaska Department of Fish and Game, personal communication). This mixture of different stock-specific run timings and uneven distribution of harvest, produce the possibility of significant differential exploitation rates between stocks or stock aggregates. This situation mandates that managers develop and maintain a rigorous monitoring program capable of assessing the adequacy of escapements throughout the geographic range of each species; further, managers must monitor those escapements to assess for trends that may be detrimental to the overall vitality of salmon runs. To manage for sustained yields and conservation of individual salmon stocks, managers need escapement data and migratory timing of individual stocks accompanied by sex and age composition throughout the migratory period.

In previous years, salmon escapements were monitored using aerial surveys as indices of relative abundance and a resistance board weir (Tobin 1994) in the Tuluksak River. Aerial surveys started in 1965 and occurred sporadically until 2003 (Harper 1997; Ward et al. 2003; Whitmore et al. 2005). These surveys were infrequently used for in-season management of the Kuskokwim River fisheries because the surveys often occurred after the commercial and subsistence fishing seasons.

Monitoring total salmon escapement has been accomplished since 1991 using a resistance board weir. The resistance board weir has been routinely installed from 1991 to 1994, and from 2001 to 2006. A weir was not operated on the Tuluksak River between 1995 and 2000.

In 2004, the Tuluksak River escapement monitoring project transitioned from a cooperative agreement to a contract between the Service and the Village of Tuluksak. This contract has continued to meet the goals of the Service, Department, Working Group and the mandates of ANILCA.

The Tuluksak River salmon escapement project objectives were to: (1) count the daily passage of chum, Chinook, sockeye, pink, and coho salmon and resident fish species through a weir on the Tuluksak River; (2) describe run-timing using daily passage counts of chum, Chinook, sockeye, pink, and coho salmon passing through the weir; (3) estimate weekly age and sex composition of chum, Chinook, and coho salmon passing through the weir; (4) determine the length of chum, Chinook, and coho salmon by age and sex; (5) enumerate chum, Chinook, sockeye, pink, and coho salmon carcasses washing onto the weir each day. These data will support the in-season management of the Kuskokwim River subsistence and commercial fisheries. The data will also aid decisions in setting biological escapement goals to maintain the sustainability of salmon resources.

Study Area

The Tuluksak River is one of several tributaries flowing into the lower Kuskokwim River and is located approximately 116 rkm northeast of Bethel, AK (Whitmore et al. 2005). The Tuluksak River is approximately 137 rkm in length and its watershed encompasses approximately 2,098 km^2 (Harper 1997) (Figure 1). It originates in the Kilbuck Mountains and flows to the northwest. The Fog River drains into the lower portion of the Tuluksak River and is the only major tributary. The Tuluksak River is a medium gradient river for the majority of its length and is characterized by dense overhanging vegetation and cut banks. The lower portion of the river is characterized by low-gradient, silty substrate and turbid waters.

The river section at the weir site, approximately 49 rkm from the mouth, is 42 meters wide, shallowest in mid-river and deepest near the banks. The substrate contains primarily sand mixed with fine gravel. Water clarity is moderately clear but can become turbid during rainy periods and when boat traffic is present.

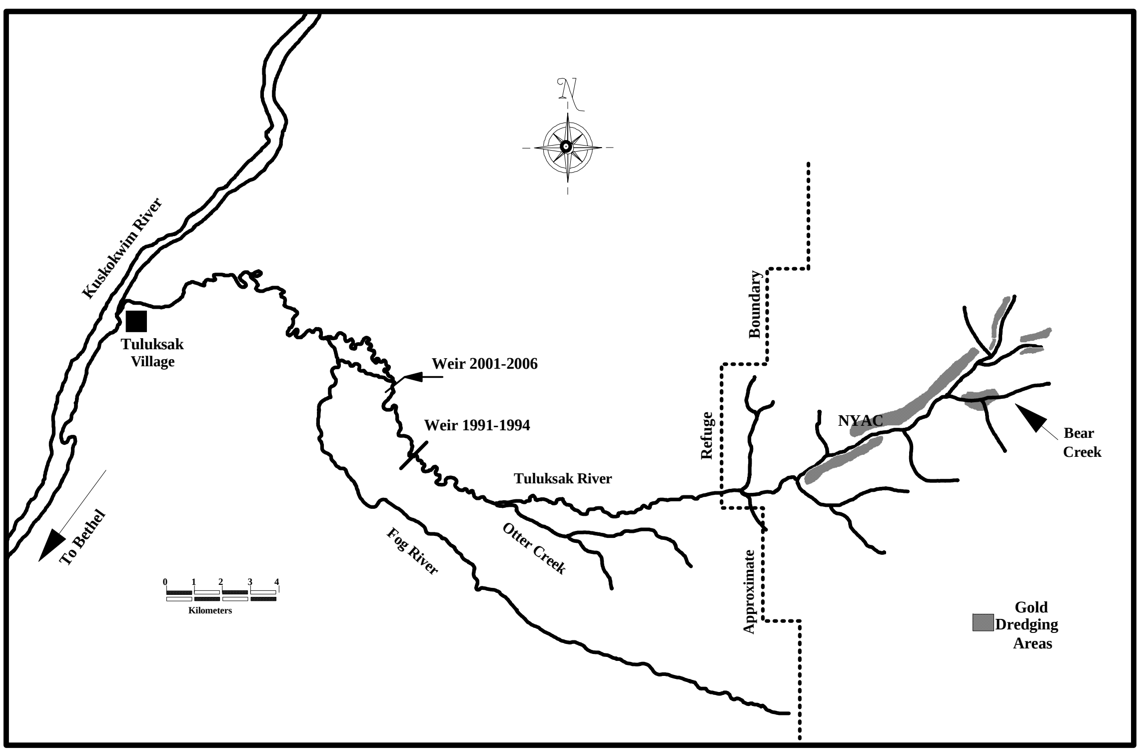

FIGURE 1.—Tuluksak River weir location, Yukon Delta National Wildlife Refuge, 1991-1994 and 2001-2006.

Methods

Weir Operations

A resistance board weir (Tobin 1994) was installed in 2006 in the Tuluksak River at rkm 49 (61°02.641') (W160°35.049'). This location is approximately 16 rkm downstream from the weir site used between 1991 and 1994 (Harper 1995a, 1995b, 1995c, 1997). The weir was relocated to a position down stream of known salmon spawning areas. The lower site also provides easier boat access to the weir and camp site during low water conditions.

This weir was modified slightly from the previous weir design used between 1991 and 1994 (Tobin 1994). A range of modifications took place in 2001 to increase efficiency of installation, operations, and takeout (Gates and Harper 2002).

Two passage panels were installed; one with an attached live trap. Counts started at approximately 0800 hours every day and continued until visibility was too poor to identify salmon by species. All passing salmon and resident fish were identified to species and recorded.

A stream gauge was installed near the shore on the river right bank approximately 10 meters downstream of the weir. The stream gauge (cm) was read twice daily and noted in the field log. To compensate for the placement of the stream gauge and to have it more accurately reflect the water depth across the river, an average water depth and stream gauge reading were taken simultaneously post installation. Water temperatures were recorded twice daily using a standard thermometer (ºC). Temperature data were then averaged for each day.

Biological Data

Statistical weeks started on a Sunday and continued through the following Saturday (Harper 1997). Target sample size consisted of 210 chum and Chinook salmon, and 170 coho salmon each week. Sampling for sockeye salmon was opportunistic and a sample of 150 fish for the season was sought. Biological sampling occurred between Monday and Thursday of each statistical week in order to obtain a snapshot sample (Geiger et al. 1990). Once the quota was met for a particular species, sampling would stop for that species and continue for others but typically would not extend past Thursday. Chinook salmon were actively sampled throughout the season (Linderman et al. 2002). Although weir passage was stratified into statistical weeks before the field season began, strata for the analysis of Pacific salmon biological data at the Tuluksak River weir were modified following the field season to represent actual weir passage.

For some salmon species, the sample size goal was expected to be a substantial fraction of the passage in some weeks. Therefore, during weeks of low passage when the maximum sample size goal could not be practically obtained, about 20% of the weekly escapement was sampled. This was sufficient to describe the age composition and reduce fish numbers handled at the weir.

Age, sex, and length data were collected from each sampled salmon. Sampled fish were caught using the live trap attached to the passage chute. A fyke gate, installed on the entrance of the trap, allowed fish to enter and at the same time minimized the number of fish exiting the trap downstream. Sampling occurred when approximately 40 fish were in the trap. To avoid potential bias caused by the selection or capture of individual fish, all target species within the trap were included in the sample even if the sample size goal for a species was exceeded. Four scales were extracted from Chinook, coho, and sockeye salmon and one was extracted from chum salmon for age determination. All scales were taken from the preferred area using methods described by Koo (1962) and Mosher (1968). Sex was determined by observing external characteristics, and length was measured to the nearest 5 millimeters from the mid-eye to the fork of the caudal fin. All data was recorded and then transferred to mark-sense forms at the end of each sample day. Mark-sense forms were processed by the Department when their personnel completed aging of the scales.

Salmon carcasses that washed onto the weir were counted by species and passed downstream. Each crew member counted carcasses when they began a counting shift, resulting in the weir being cleaned at least every four hours.

Salmon ages were reported according to the European Method (Koo 1962) where numerals preceding the decimal denote freshwater annuli and numerals following the decimal denote marine annuli. Total years of life at maturity is determined by adding one year to the sum of the two digits on either side of the decimal (i.e. age 1.4 and 2.3 (1.4=1+4+1=6 and 2.3=2+3+1=6) are both six-year-old fish from the same parent year). The parent year is determined by subtracting fish age from the current year.

Characteristics of fish passing through the weir were estimated using standard stratified random sampling estimators (Cochran 1977). Within a given stratum m, the proportion of species i passing the weir that are of sex j and age k (pijkm) was estimated as

$$\hat{p}_{ijkm} = \frac{n_{ijkm}}{n_{i++m}},$$

where n_{ijkm} denotes the number of fish of species i, sex j, and age k sampled during stratum m and a subscript of "+" represents summation over all possible values of the corresponding variable, e.g., n_{i++m} denotes the total number of fish of species i sampled in stratum m. The variance of $\hat{p}_{ijkm}$ was estimated as

$$\hat{v}\left(\hat{p}_{ijkm}\right) = \left(1 - \frac{n_{i++m}}{N_{i++m}}\right)\frac{\hat{p}_{ijkm}\left(1 - \hat{p}_{ijkm}\right)}{n_{i++m} - 1},$$

where N_{i++m} denotes the total number of species i fish passing the weir in stratum m. The estimated number of fish of species i, sex j, age k passing the weir in stratum m (N_{ijkm}) is

$$\hat{N}_{ijkm} = N_{i++m}\,\hat{p}_{ijkm},$$

with estimated variance

$$\hat{v}\left(\hat{N}_{ijkm}\right) = N^2_{i++m}\,\hat{v}\left(\hat{p}_{ijkm}\right).$$

Estimates of proportions for the entire period of weir operation were computed as weighted sums of the stratum estimates, i.e.,

$$\hat{p}_{ijk} = \sum_m \left(\frac{N_{i++m}}{N_{i+++}} \right) \hat{p}_{ijkm}$$

with estimated variance

$$\hat{v}\left(\hat{p}_{ijk}\right) = \sum_m \left(\frac{N_{i++m}}{N_{i+++}} \right)^2 \hat{v}\left(\hat{p}_{ijkm}\right).$$

The total number of fish in a species, sex, and age category passing the weir during the entire period of operation was estimated as

$$\hat{N}_{ijk} = \sum_m \hat{N}_{ijkm} ,$$

with estimated variance

$$\hat{v}\left(\hat{N}_{ijk}\right) = \sum_m \hat{v}\left(\hat{N}_{ijkm}\right).$$

If the length of the rth fish of species i, sex j, and age k sampled in stratum m is denoted x_{ijkmr}, the mean length of all such fish (μ_{ijkm}) was estimated as

$$\hat{\mu}_{ijkm} = \left(\frac{1}{n_{ijkm}} \right) \sum_r x_{ijkmr} ,$$

with corresponding variance estimator

$$\hat{v}\left(\hat{\mu}_{ijkm}\right) = \left(1 - \frac{n_{ijkm}}{\hat{N}_{ijkm}} \right) \frac{\sum_r \left(x_{ijkmr} - \hat{\mu}_{ijkm} \right)^2}{n_{ijkm}\left(n_{ijkm} - 1\right)}$$

The mean length of all fish of species i, sex j, and age k (μ_{ijk}) was estimated as a weighted sum of the stratum means, i.e.,

$$\hat{\mu}_{ijk} = \sum_m \left(\frac{\hat{N}_{ijkm}}{\hat{N}_{ijk}} \right) \hat{\mu}_{ijkm}$$

An approximate estimator of the variance of $\hat{\mu}_{ijk}$ was obtained using the delta method (Seber 1982),

$$\hat{v}(\hat{\mu}_{ijk}) = \sum_{m}\left\{\hat{v}(\hat{N}_{ijkm})\left[\frac{\hat{\mu}_{ijkm}}{\sum_{x}\hat{N}_{ijkx}} - \sum_{y}\frac{\hat{N}_{ijky}\,\hat{\mu}_{ijky}}{\left(\sum_{x}\hat{N}_{ijkx}\right)^{2}}\right]^{2} + \left(\frac{\hat{N}_{ijkm}}{\sum_{x}\hat{N}_{ijkx}}\right)^{2}\hat{v}(\hat{\mu}_{ijkm})\right\}$$

A chi-square test of independence (Agresti 1990) was used to test the hypothesis of independence of sex and age, by species. Because a fundamental assumption of the test is that the data are derived from a single random sample, the test was modified to accommodate a stratified random sampling design. Using the first order approximation of Rao and Thomas (1989), the usual test statistic was divided by the mean generalized design effect. A significance level of $\alpha = 0.05$ was used.

A two-sample t-test $\alpha = 0.05$ (Systat 11.0) was used to test the hypothesis that male and female fish of age k have equal mean lengths. Data were pooled across all strata and treated as one sample to compare lengths.

Days with partial counts were considered incomplete and were reported as zero counts. Estimates were calculated for these dates and were based on the average daily proportion of passage from data collected between 1991-1993 and 2002-2005. An average of the daily proportions for previous years data was calculated since daily escapement can vary between years. The sum of the averaged daily proportions, calculated for days with zero counts, is the estimated total escapement missed. The total escapement is the sum of the observed counts during 2006 divided by one minus the proportion missed in 2006. Estimates were calculated for portions of 1994 and 2001 (Gates and Harper 2002; Harper 1997). These estimated counts were not used when calculating the 2006 estimates.

Results

Weir Operations

The weir was installed on June 30, 2006, and operated through September 6, 2006. During installation, the rail was reset to compensate for substrate change that occurred over winter and spring break-up. The weir was installed in the same location as 2005. Minor repairs were made to damaged weir components during the 2006 field season. The weir was removed on September 6.

Average water depth during 2006 was 113 cm. The minimum water depth of 50 cm occurred on July 22 and the river rose to a maximum depth of 265 cm on August 20 (Appendix 1). Water temperatures averaged 10°C, and ranged from 7.5°C on September 1 to 14°C on July 22 (Appendix 1).

Biological Data

Chum Salmon—A total of 23,932 chum salmon passed through the weir from July 1 to September 6. Forty-eight chum salmon that passed the weir (<1%) were observed with gill net marks. Peak weekly passage (N=7,098), representing 30% of the escapement, occurred between July 16 and July 22 (Figure 2). The observed median cumulative passage date occurred on July

18 (Appendix 2). An estimated 1,716 chum salmon passed the weir pre- and post-weir operations and during the high water event from August 14 to 28 for a total estimated passage of 25,648 (Appendix 2).

Four age groups were identified from 1,056 chum salmon sampled from the weir escapement. Female chum salmon comprised less than 50% of the weekly passage through the majority of the run and 48% of the escapement (Figure 3, Appendix 3). Age 0.4 chum salmon were the most abundant, accounting for 51% of the aged sample (Appendix 3). There was a significant difference in age composition between sexes ($P<0.001$).

Lengths of age 0.4 chum salmon ranged from 485 to 670 mm (Appendix 4). In sampled fish, the mean length of males was greater than that of females for fish aged 0.4 (Table 1 and Appendix 4). Mean lengths of males and females of age 0.2 and 0.3 were also significantly different (Table 1 and Appendix 4). Insufficient samples were available for analysis of age 0.5 fish.

Chum salmon carcasses were first recorded on July 1. Median cumulative passage dates for escaping chum salmon and chum salmon carcasses washing onto the weir were separated by 14 days (Figure 4). A total of 3,396 chum salmon carcasses passed downstream over the weir from July 1 to September 6. It is unknown how many carcasses may have washed over the weir during high water.

TABLE 1.—Two sample *t*-test results for the test of H_0: male and female salmon of a given age have equal mean lengths. Note different ages for chum, Chinook, and coho salmon.

	Brood Year and Age Group			
	2003	2002	2001	2000
	0.2	0.3	0.4	0.5
Chum salmon				
2-tailed *t*	2.38	15.683	12.686	
degrees of freedom	37	509	503	
p -value	0.023	<.0001	<.0001	
	1.2	1.3	1.4	1.5
Chinook salmon				
2-tailed *t*		-4.051	-1.278	
degrees of freedom		47	39	
p -value		<.0001	0.209	
	1.1	2.1	3.1	4.1
Coho salmon				
2-tailed *t*	-0.312	-0.862		
degrees of freedom	8	87		
p -value	0.763	0.391		

Chinook Salmon—Chinook salmon (N=993) passed through the weir between July 1 and September 5. Twelve Chinook salmon that passed the weir, (1%) were observed with gill net marks. Peak weekly passage occurred between July 16 and July 22 (N=353) (Figure 2). The median cumulative passage date occurred on July 19 (Appendix 2). An estimated 51 Chinook salmon passed the weir prior to weir installation and during the high water event from August 14 to 28 for a total estimated passage of 1,044 (Appendix 2).

Four age groups were identified from 149 Chinook salmon sampled between July 4 and August 9 (Appendix 5). Female Chinook salmon comprised less than 30% of the weekly passage through the first half of the run, and composed an estimated 28% of the total escapement (Figure 3, Appendix 5). Age 1.2 and 1.3 dominated the Chinook salmon escapement with 37%, and 33%, and age 1.4 accounted for 28% (Appendix 5). Age 1.5 was present in the 2005 sample. Age composition differed between sexes (P<0.001). Males were primarily age 1.2 (36%), and females were predominantly age 1.4 (19%) (Appendix 5).

Lengths at age for 1.2 and 1.3 Chinook salmon ranged from 470 to 840 mm (Appendix 6). Mean lengths of age 1.3 females was greater than that of same aged males (Table 1 and Appendix 6). Mean lengths of age 1.4 males and females were not significantly different (Table 1 and Appendix 6). Insufficient samples were available for comparison of same age males and females in age groups 1.2 and 1.5.

Chinook salmon carcasses (N=298) were observed on the weir starting July 13. The median cumulative passage dates for daily escapement and carcasses were separated by 20 days (Figure 4). It is unknown how many carcasses may have washed over the weir during high water.

Sockeye Salmon—Sockeye salmon (N=920) passed the weir between July 3 and September 5. Seven sockeye salmon that passed the weir (<1%) were observed with gill net marks. Peak weekly passage occurred between July 16 and 22 (N=343) (Figure 2), with a median cumulative passage date of July 20 (Appendix 2). An estimated 65 sockeye salmon passed the weir prior to installation and during the August 14 to 28 high water event for a total estimated passage of 985 (Appendix 2).

Forty-two sockeye salmon carcasses were counted on the upstream side of the weir during 2006. The first carcass washed onto the weir on July 7, four days after the first sockeye salmon passed through the weir. It is unknown how many carcasses may have washed over the weir during high water.

Pink Salmon—Pink salmon (N=2,093) passed the weir between July 4 and September 6. Five pink salmon that passed the weir (<1%) were observed with gill net marks. Peak weekly passage was observed between July 16 and 22 (N=736) (Figure 2). The median cumulative passage date was July 20 (Appendix 2). An estimated 355 pink salmon passed the weir pre- and post-weir operations and during the high water event from August 14 to 28 for a total estimated passage of 2,448 (Appendix 2).

The first pink salmon carcass washed onto the weir on July 16, twelve days after the first pink salmon was counted through the weir. The median cumulative passage dates for daily escapement and carcasses were separated by 14 days (Figure 4). Three hundred forty-six pink salmon carcasses were counted on the weir during operations, which accounted for 17% of the pink salmon counted through the weir. It is unknown how many carcasses may have washed over the weir during high water.

Coho Salmon—Coho salmon (N=2,393) passed through the weir between July 20 and September 5. Gillnet marks (N=39) were observed on 2% of the coho salmon passing the weir. Sixty-one percent of the coho salmon run in 2006 was derived from estimates of daily escapement using historical average daily proportions of fish passage on similar days. Peak weekly passage (N=1,788) was estimated to occur between August 20 and August 26 (Figure 2). The median cumulative passage date occurred on August 26 (Appendix 2). An estimated 3,745 coho salmon passed the weir during the August 14 to 28 high water event and after weir operations for a total estimated passage of 6,138 (Appendix 2).

Three age classes were identified from 102 sampled coho salmon. The majority (90%) of the coho salmon were age 2.1 (Appendix 7). The remaining sample was comprised of age 1.1 (8%) and 3.1 (2%) fish. Females composed 54% of the coho salmon escapement (Figure 3; Appendix 7). Age composition did not differ between sexes ($P>0.05$). Mean lengths were not significantly different ($P>0.05$) for age 2.1 males and females (Table 1 and Appendix 8). Insufficient length composition data were available for age 1.1 and 3.1 (Appendix 8).

The first coho salmon carcass was recorded on August 4. By September 6, 2005, when the weir was removed, only six coho salmon carcasses were passed.

Resident Species—Resident species counted through the weir consisted of six Dolly Varden, 19 whitefish, five northern pike, and six Arctic grayling. Although smaller sized resident species were able to pass freely through the pickets, passage through the passage chutes was recorded throughout the entire season. Three whitefish and two Arctic grayling carcasses were recorded on the weir.

Discussion

Weir Operations

Weir installation was delayed by high water depths and flows during the normal installation time. Heavy rainstorms at the end of July and throughout August increased water levels substantially and hindered weir operations from August 14 to 28. Due to continuing rains and rising water conditions, the weir was removed on September 6, four days before usual removal on September 10. The decision to discontinue weir operations earlier than usual was made in conjunction with the Department. The substrate rail and cable were left in place to expedite installation in 2007.

Biological Data

Chum Salmon—The estimated chum salmon escapement in 2006 (N=25,648) was within the historic range of 7,675 to 35,696 fish (Figure 5), and above the historical average (N=14,695) (Gates et al 2002; Harper 1995a, b, c, Harper 1997; Zabkar et al. 2006). Despite high water events, the 2006 escapement was 72% of the 2005 chum salmon escapement (N=35,696), which is the highest escapement on record. The median passage date for chum salmon occurred on July 18 (Figure 6), three days earlier than the historical average of July 21 (Gates and Harper 2003; Zabkar and Harper 2004).

Other escapement projects located on Kuskokwim River tributaries indicate the 2006 chum salmon escapement was above the recorded average. The sonar project on the Aniak River, achieved the sustainable escapement goal for the fifth year in a row. Chum salmon escapement at the Kwethluk, George, and Takotna river monitoring projects were the highest on record, and above average at the Tatlawiksuk River weir (Linderman and Bue 2006).

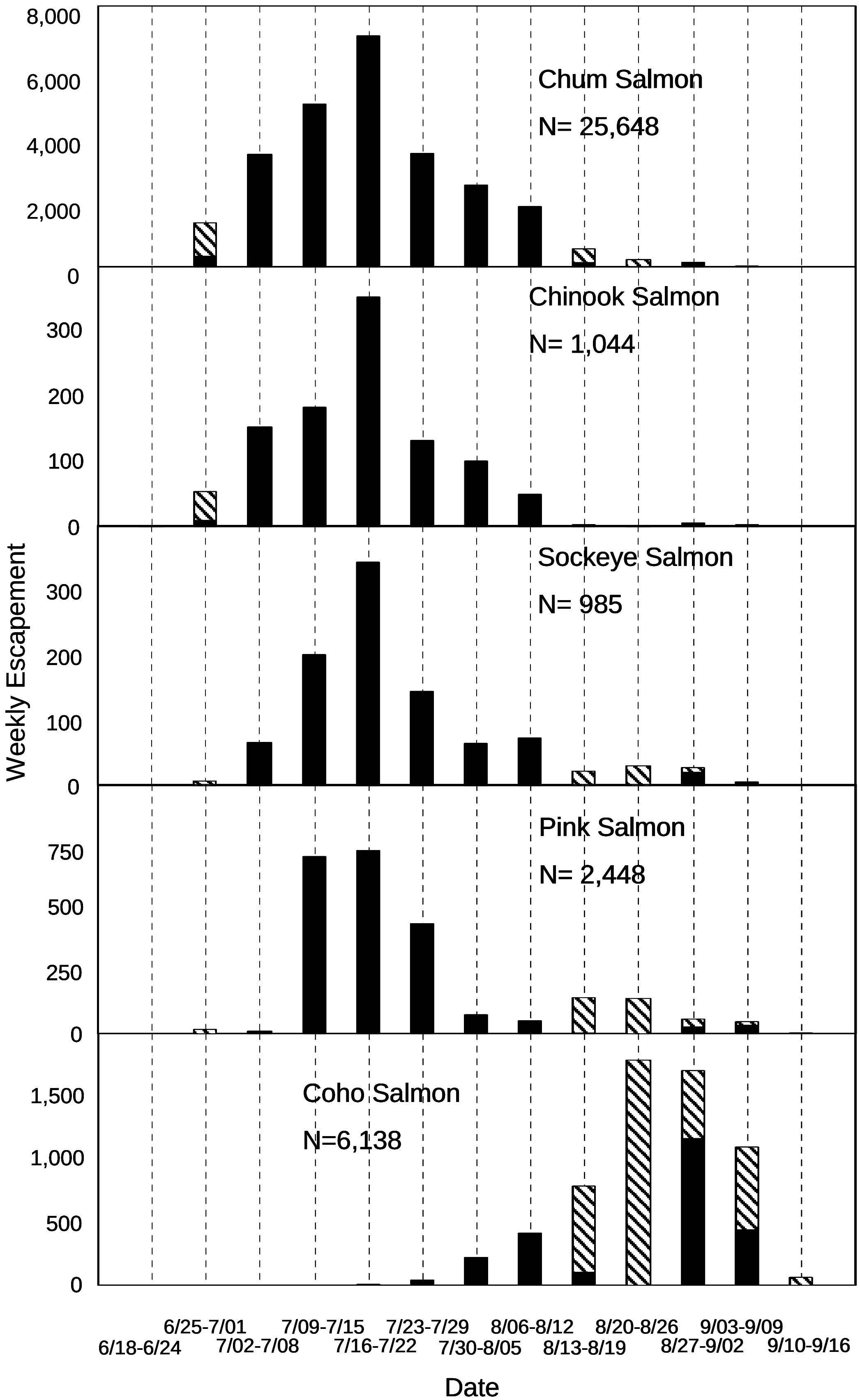

FIGURE 2.—Weekly chum, Chinook, sockeye, pink, and coho salmon escapements through the Tuluksak River weir, 2006. Hash marked bars represent estimated portions of the salmon migration.

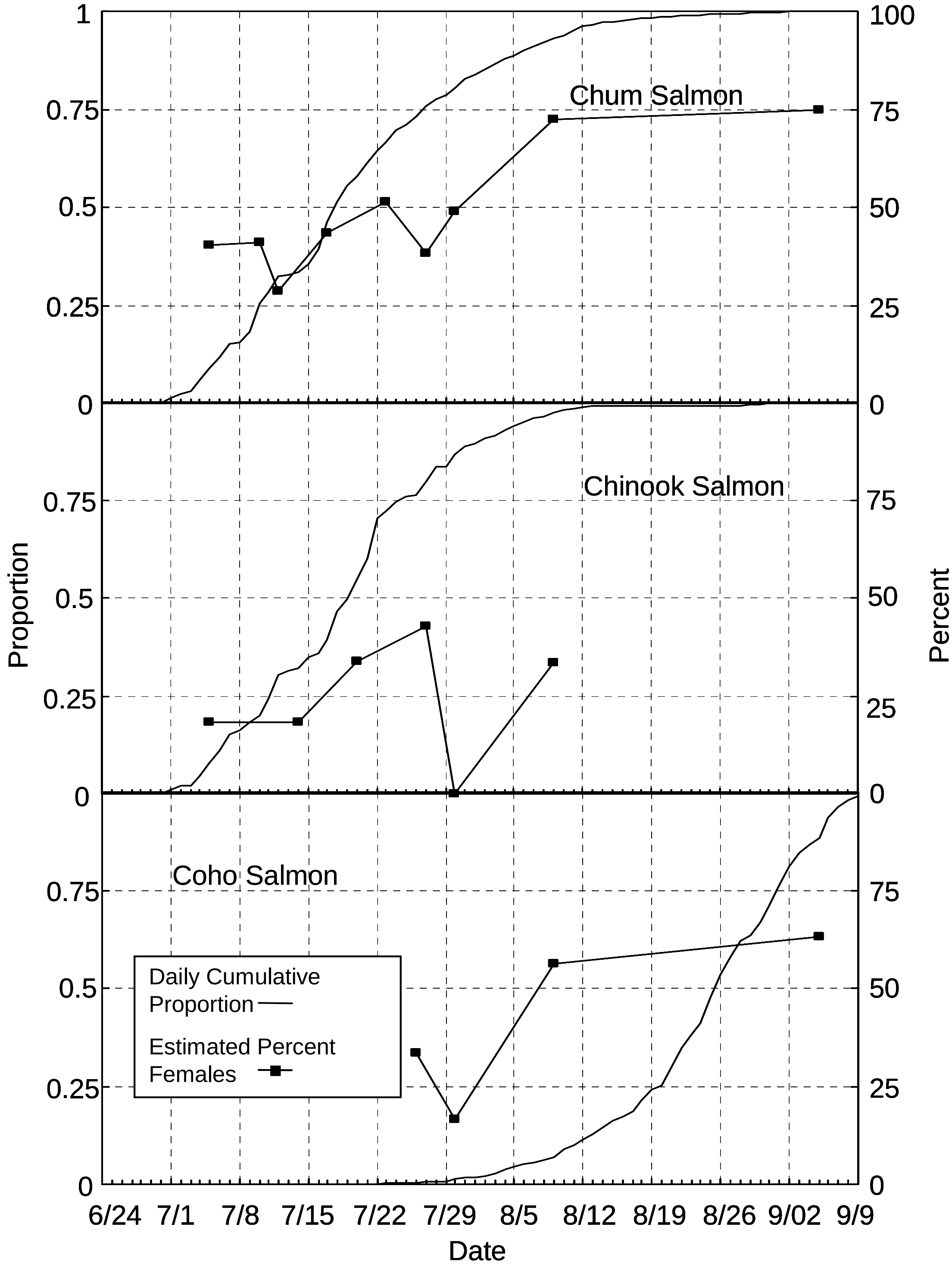

FIGURE 3.—Cumulative proportion and percent females of chum, Chinook, and coho salmon through the Tuluksak River weir, 2006.

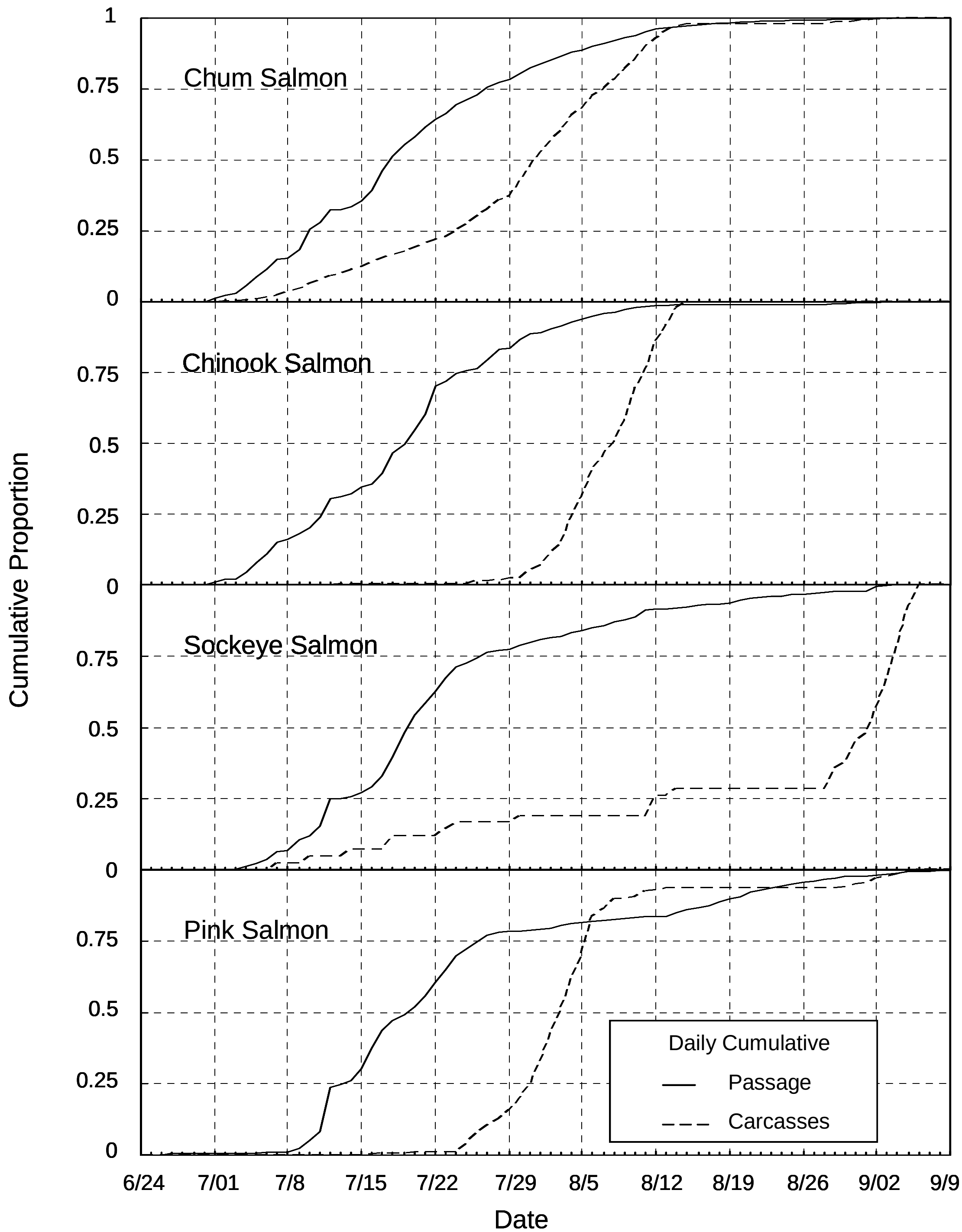

FIGURE 4.—Cumulative proportion of chum, Chinook, sockeye and pink salmon passage and carcasses washing onto the upstream side of the Tuluksak River weir, 2006.

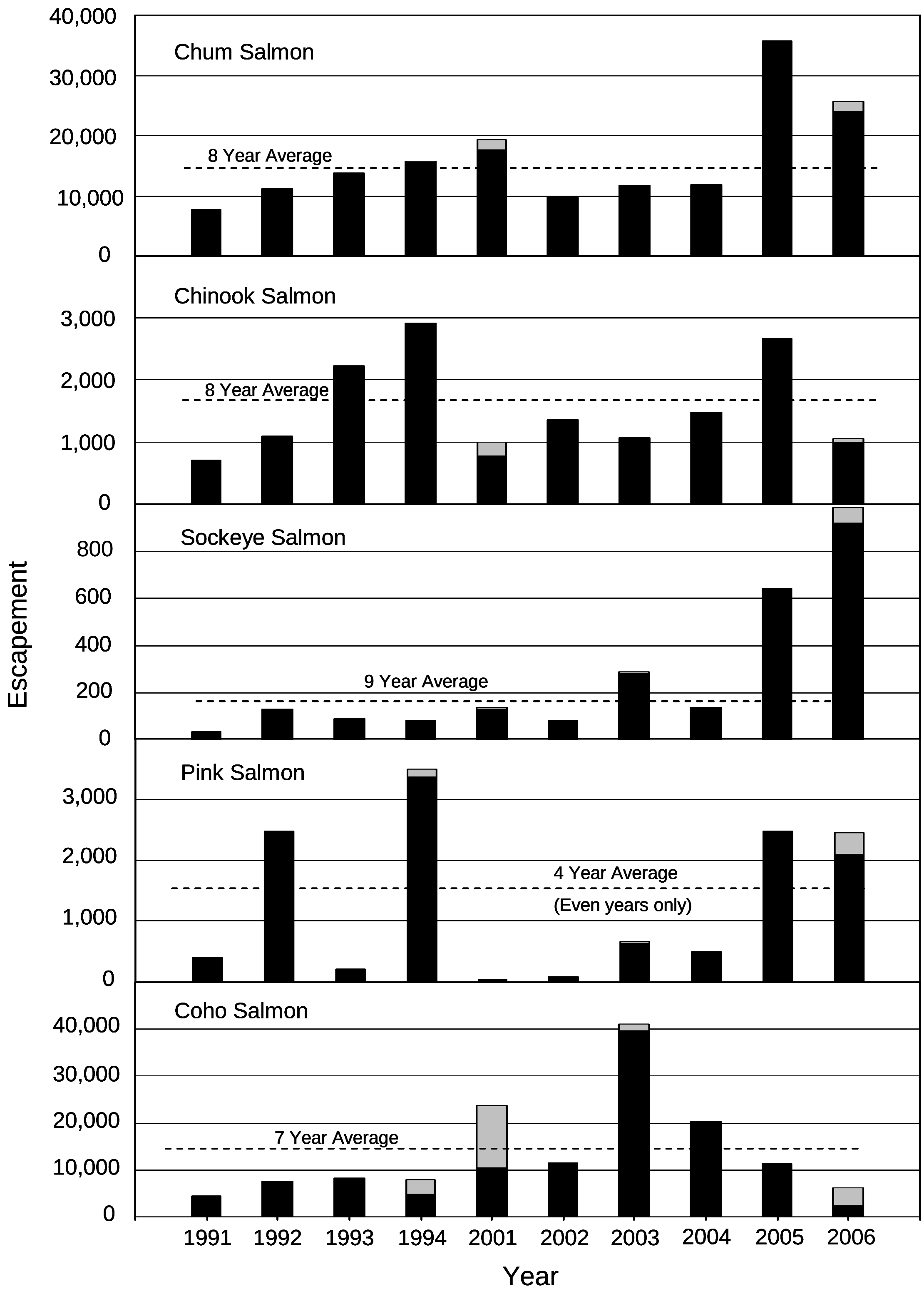

FIGURE 5.—Salmon escapements through the Tuluksak River weir, 1991-1994 and 2001-2006. Note shading for estimated counts. Averages were calculated using only years with complete counts. The y-axis uses different scales.

Males and females were almost equally represented in the total escapement with 52% males and 48% females. Males were dominant in early weekly passage estimates, but females became the more abundant sex in late July and continued this trend throughout the remainder of the season (Figure 3, Appendix 3). More females were in age classes 0.2 and 0.3, bringing the total escapement close to the male chum salmon escapement. The proportion of females and males was very similar for ages 0.3 and 0.4. The percent of females in 2006 was similar to the earlier years of operation, from 1991 to 1994 where the percent female was 48% to 52% (Harper 1995a, 1995b, 1995c, 1997). In more recent years the percent of female chum salmon has been less than 50%, ranging from 33% to 44% from 2001 to 2005 (Gates and Harper 2002, 2003; Zabkar and Harper 2004; Zabkar et al. 2006).

Age 0.4 chum salmon comprised 51% of the return in 2006, an increase in that age over previous years. Males and females of age 0.3 each represented 23% of the total escapement while age 0.2 represented <3% of the return. The high percentage of age 0.3 and 0.4 chum salmon were from the 2002 and 2001 brood years. Prior to 2005, which now holds the highest escapement on record, 2001 had the highest escapement of chum salmon. As a result we have seen high sibling returns of age 0.3 during 2005, and high returns of age 0.4 during 2006 (Gates and Harper 2003; Zabkar and Harper 2004).

Gill net marks (N=48) were observed on <1% of the chum salmon passing the weir, similar to 2003-2005, which also returned <1% gill net marked chum salmon observed at the weir (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004; Zabkar et.al 2006). Gill net marks were more frequently observed during years when a commercial harvest of chum salmon occurred in late June and early July, as confirmed in 1991 and 1992 (5% and 4%, respectively) when commercial fishing occurred. Commercial fishing did occur between June 26 and 28, and throughout August, and Chinook, chum, sockeye, and coho salmon were harvested. The commercial fishing periods did not appear to influence the amount of gill net marks observed at the weir (<1%).

Chinook Salmon—The estimated Chinook salmon escapement during 2006 (N=1,044) was one of the lowest on record, and well below the historical average (N=1,682) (Figure 5). Run timing in 2006 was the latest on record; the median passage date occurred eight days after the average (Figure 6; Appendix 2). In the previous nine years of weir operation the Chinook salmon median passage dates were between July 5 and July 14 (Gates and Harper 2003; Zabkar and Harper 2004; Zabkar et. al 2006), but the median passage date for 2006 was July 19.

A potential explanation for the low Tuluksak River Chinook salmon numbers in 2006 may be related to the location of subsistence fisher gill nets. Many subsistence gill nets were set near the outlet of the Tuluksak River and in the plume where the Tuluksak River mixes with the Kuskokwim River, which could have targeted Tuluksak River bound Chinook salmon. The high cost of gasoline in 2006 may have influenced the location of subsistence fisher gill nets, which may have been set closer to the village than in previous years.

Salmon are known to migrate in deep water near shore (Standen et al. 2004; Quinn 2005). Chinook salmon stream bank orientation may occur in the mainstem of the Kuskokwim River downstream of the mouth of the Tuluksak River, similar to another Kuskokwim River drainage study (Stuby 2006), setting the salmon bound for the Tuluksak River on a course to subsistence gill nets.

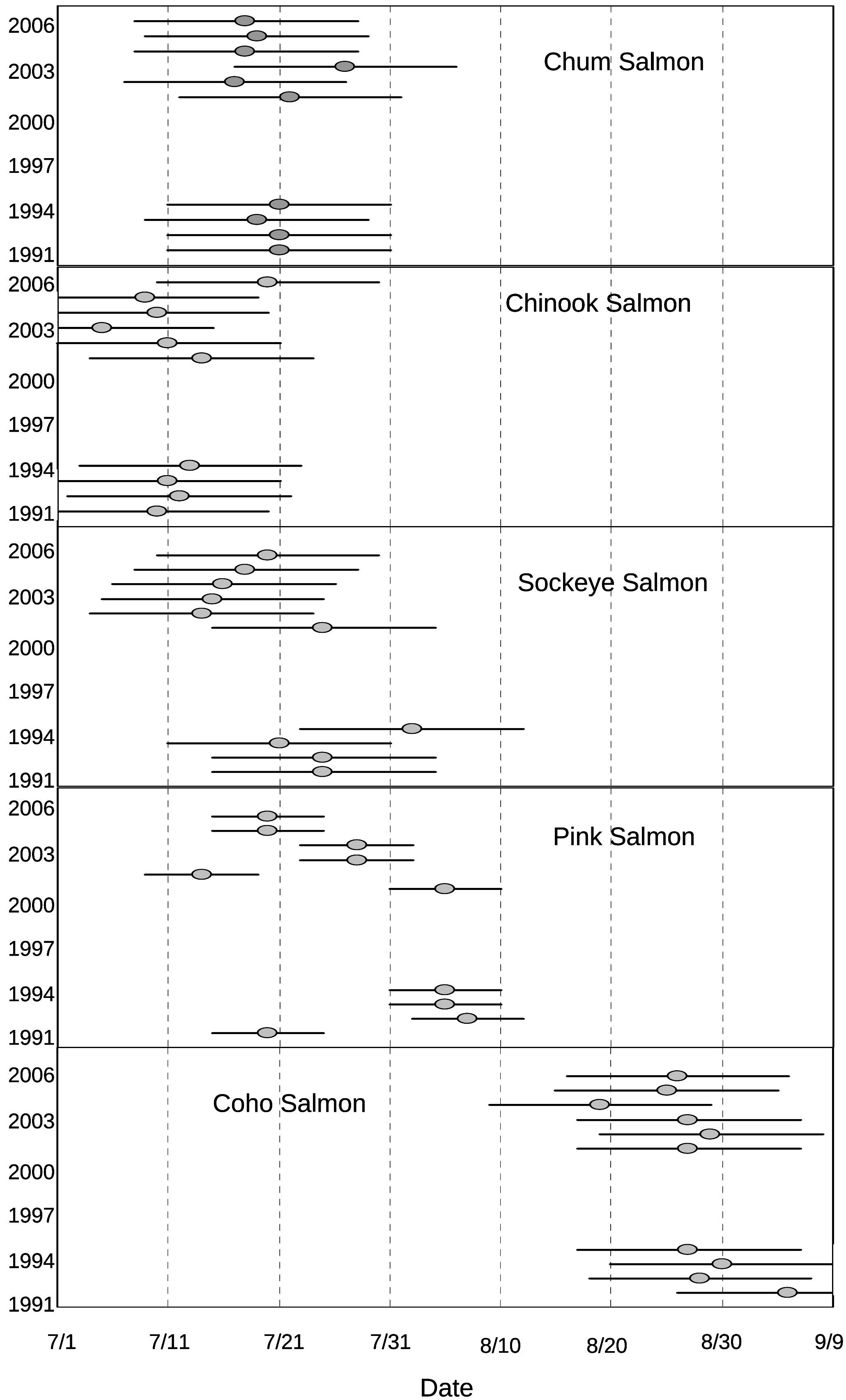

FIGURE 6.—Run timing of chum, Chinook, coho, sockeye, and pink salmon in the Tuluksak River, 1991-1994, 2001-2006. For each year, the float indicates date of median cumulative passage, the horizontal bars represent 10% error.

Similar to the past three years the 2006 subsistence-fishing schedule maintained windows of fishing opportunity in the Kuskokwim River drainage. These four-day windows of fishing and three days of closure were designed to allow for an adequate subsistence harvest and improve the quality of spawning escapement. The Kuskokwim River Salmon Management Working Group met on June 15 and determined there was sufficient abundance of Chinook salmon to meet escapement goals and amounts necessary for subsistence; therefore, on June 16, managers opened the subsistence-fishing schedule to seven days per week. The schedule was rescinded three days earlier than in 2005. The strong return of Chinook and chum salmon allowed many Kuskokwim River tributaries to meet their escapement goals and subsistence users were able to harvest an adequate number of fish.

A comparison of Chinook salmon age and sex data from samples in the commercial fishery in District W-1, the subsistence fishery in the lower Kuskokwim River, and escapement at the Tuluksak River weir clearly shows the influence of gill net selectivity (Figure 7). Gill net mesh size of subsistence fishers is not regulated; and many use large mesh sizes (stretched mesh size 8 inches or greater) when targeting Chinook salmon (Molyneaux et al. 2005). In 1985, commercial fishers were restricted to use gill nets with less than 6 inches mesh size. Large mesh sized gill nets harvest older, larger fish, and small mesh sizes harvest smaller fish. Subsistence fishery numbers were pooled for all subsistence fishers on the lower Kuskokwim River and may not be representative of theTuluksak River subsistence fishery. It is important to take a closer look at the subsistence harvest from the Tuluksak River: is the combination of larger mesh size and placement of nets responsible for the low number of Chinook salmon escapement at the weir?

Historically, Tuluksak River Chinook salmon returns were dominated by age 1.2, 1.3 and 1.4 fish. Similarly, the dominant age groups in 2006 were age 1.2, 1.3, and 1.4, representing 37%, 33%, and 28% of the total escapement. If the return of siblings holds, there should be a high return of age 1.3 Chinook salmon in 2007.

Females in previous years (1991 – 1994 and 2002 – 2005) have represented between 14% and 37%, and an average of 26% of the annual runs (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004; Zabkar et al. 2006). In 2006, escapement of female Chinook salmon was above average (28%), yet it is important to consider that this number was derived from one of the lowest Chinook salmon escapements in the history of the Tuluksak River weir.

Gill net marks (N=12) were observed on 1% of the Chinook salmon that passed the weir. Historically, gill net marks have ranged from 1 to 10% (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004; Zabkar et. al 2006). Similar to chum salmon, a higher percentage of gill net marks are typically present during years with commercial fishing periods occurring late June and early July (1991 and 1992; 10%) (Harper 1997). Commercial fishing began on June 26 on the Kuskokwim River and only 2,777 Chinook salmon were commercially harvested (Linderman and Bue 2006). Observed gill net marks at the weir remained similar to those years without a fishery.

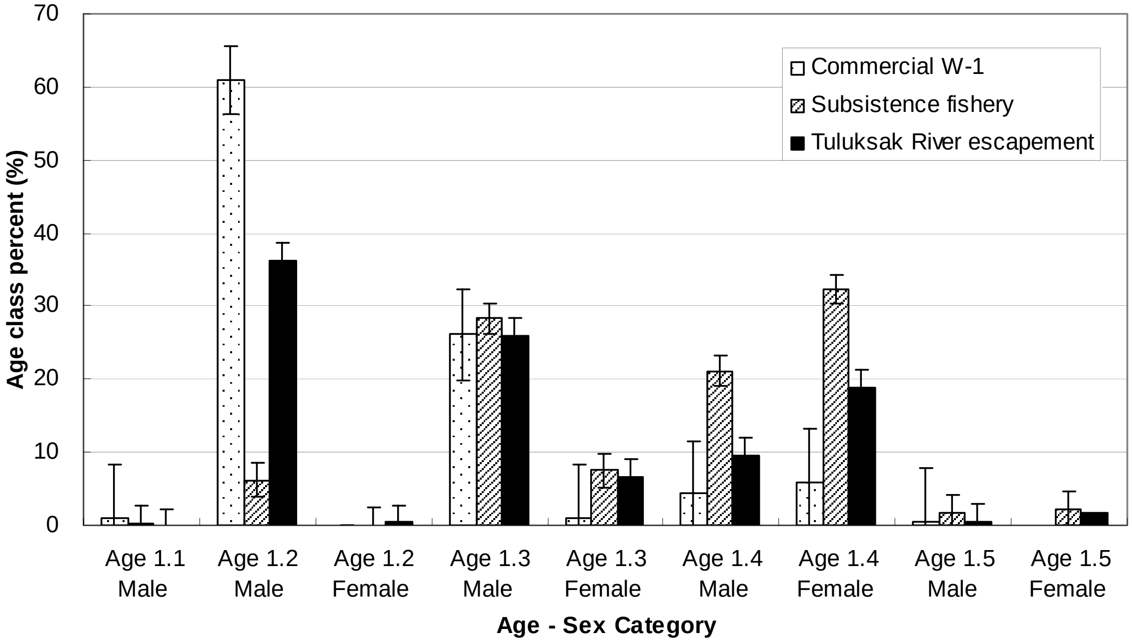

FIGURE 7.—Age and sex composition of Chinook salmon sampled from the 2006 Kuskokwim River commercial and subsistence harvest, and estimated age and sex composition of escapement through the Tuluksak River weir. (+/- SE at the top of each bar)

Sockeye Salmon—Historically, the total number of sockeye salmon passing the Tuluksak River weir was consistently small (N<150). In 2006, the sockeye salmon escapement (N=985) was the highest escapement on record (Figure 6). Similarly, other escapement projects located on the Kuskokwim River tributaries had strong sockeye salmon returns. Sockeye salmon returns to the Kogrukluk and Kwethluk river weirs were the highest on record (Linderman and Bue 2006).

Fifty percent of sockeye salmon had passed the weir by July 20, six days after the earliest median passage date on record. Median passage dates have previously ranged between July 14 and August 1 (Gates and Harper 2003; Zabkar and Harper 2004; Zabkar et. al 2006).

Currently, sockeye salmon are not actively managed in the lower Kuskokwim River commercial fishing districts from the mouth of the Kuskokwim River up to the village of Tuluksak (Ward et al. 2003). The 2006 commercial catch was less than the recent 10-year average harvest of sockeye salmon (Linderman and Bue 2006).

Pink Salmon—Kuskokwim River pink salmon typically have strong even-year runs (Francisco et al. 1992). This was observed at the Tuluksak River weir for all even years except 2002 (Figure 5). In 2006, the estimated pink salmon escapement (N=2,448) returned in greater strength than the even year average escapements (N=1,620), and stronger than the odd year average escapements (N=758). Pink salmon escapements during previous years of operation have ranged from 27 to 3,374 fish (1991-1994, and 2001-2004). The median passage of July 20 was the second earliest date on record, next to July 14, 2002 (Harper 1995b, 1997; Gates and Harper 2003). Currently, pink salmon escapement goals have not been established and very little is known about the Kuskokwim River pink salmon stocks.

Coho Salmon—Overall, 61% of the coho salmon run in 2006 was estimated. Forty-nine percent of that estimate was due to the high water event during the historic peak of the coho salmon run in mid- August. Twelve percent of the escapement estimate was due to the threat of another high water event at the end of the season, which resulted in an early weir removal. The 2006 coho salmon escapement estimate was approximately 41% of the historical average. This return was below the past five years of escapement on the Tuluksak River (Figure 5). Similarly, average to below average returns occurred in other Kuskokwim tributaries during 2006. The only exceptions were at the Takotna River weir which had above average escapement and the Kalskag tagging project where coho salmon catches were above the 2005 catch (Linderman and Bue 2006).

Run timing in 2006 was average compared to all previous years of weir operations (Figure 6). The estimated median passage date for coho salmon, August 26, was two days before the average, August 28 (Appendix 2). The range of previous year's median passage dates were August 19 to September 5 (Gates and Harper 2003; Zabkar and Harper 2004).

Similar to past years, age 2.1 was the dominate age group for 2006, representing an estimated 90% of the escapement. Ages 1.1 and 3.1 were present in the escapement. Age 2.1 has been the primary age group in all years of operations. Females age 2.1 in 2006 made up 47% of the escapement, resulting in a high percentage of total females (54%) in the escapement. The range of percent females in previous years was 32% to 58% (Harper 1995a, 1995b, 1995c, 1997; Gates and Harper 2002, 2003; Zabkar and Harper 2004; Zabkar et al. 2006).

The percentage of gill net marks in the 2006 weir escapement was 2% compared to previous years, 2% - 9% (Harper 1995a, 1995c; Gates and Harper 2003; Zabkar and Harper 2004; Zabkar et. al 2006). Coho salmon escapements for 1994, 2001, and 2003 were estimated; therefore the recorded gill net marks for these years is not an accurate representation. The number of gill net marks has decreased with the decrease of commercial fishing time and harvest of coho salmon. In 2006, seventeen commmercial fishing periods occurred between August 1 and August 30 for coho salmon. Lower gill net marks may be due in part to the smaller size of the coho salmon, which could have slipped through the gill nets (Linderman and Bue 2006).

Acknowledgements

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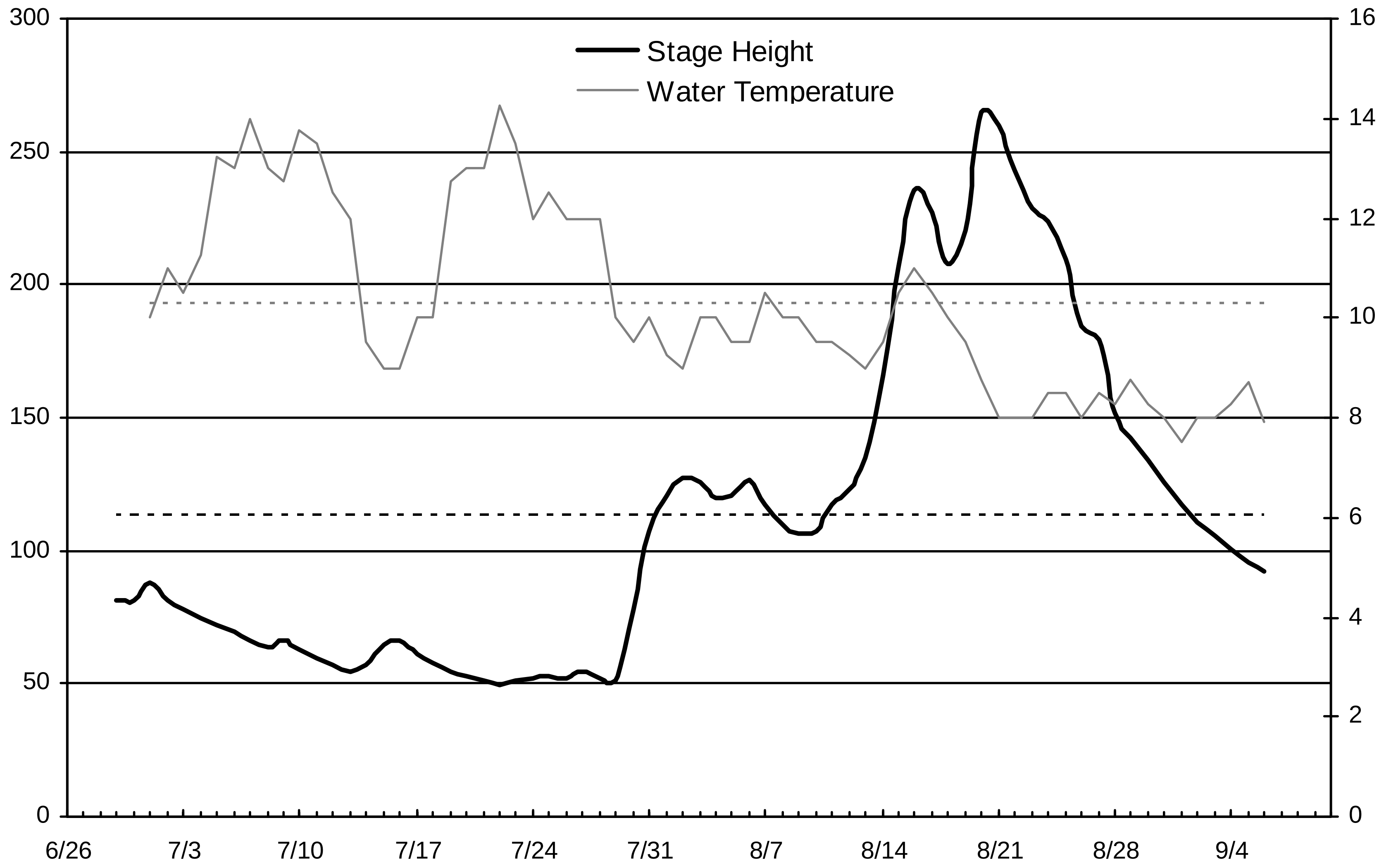

APPENDIX 1.—River stage heights and water temperatures at the Tuluksak River weir, 2006.

APPENDIX 2.—Daily, cumulative, and cumulative proportion of chum, Chinook, sockeye, pink, and coho salmon passing through the Tuluksak River weir, Alaska, 2006.

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
6/24 *	9	9	0.000	1	1	0.001	0	0	0.000	0	0	0.000	0	0	0.000
6/25 *	50	59	0.002	1	2	0.002	0	0	0.000	0	0	0.000	0	0	0.000
6/26 *	67	126	0.005	1	3	0.003	2	2	0.002	4	4	0.002	0	0	0.000
6/27 *	146	272	0.011	2	5	0.005	4	6	0.006	9	13	0.005	0	0	0.000
6/28 *	204	476	0.019	10	15	0.014	0	6	0.006	1	14	0.006	0	0	0.000
6/29 *	122	598	0.023	19	34	0.033	0	6	0.006	1	15	0.006	0	0	0.000
6/30 *	421	1,019	0.040	13	47	0.045	1	7	0.007	2	17	0.007	0	0	0.000
7/1	339	1,358	0.053	9	56	0.054	0	7	0.007	0	17	0.007	0	0	0.000
7/2	214	1,572	0.061	11	67	0.064	0	7	0.007	0	17	0.007	0	0	0.000
7/3	215	1,787	0.070	1	68	0.065	4	11	0.011	0	17	0.007	0	0	0.000
7/4	656	2,443	0.095	22	90	0.086	11	22	0.022	1	18	0.007	0	0	0.000
7/5	758	3,201	0.125	35	125	0.120	10	32	0.032	0	18	0.007	0	0	0.000
7/6	680	3,881	0.151	31	156	0.150	13	45	0.046	4	22	0.009	0	0	0.000
7/7	854	4,735	0.185	42	198	0.190	26	71	0.072	5	27	0.011	0	0	0.000
7/8	67	4,802	0.187	11	209	0.200	2	73	0.074	1	28	0.011	0	0	0.000
7/9	733	5,535	0.216	20	229	0.220	37	110	0.112	29	57	0.023	0	0	0.000
7/10	1,811	7,346	0.286	18	247	0.237	16	126	0.128	69	126	0.051	0	0	0.000
7/11	628	7,974	0.311	40	287	0.275	31	157	0.159	78	204	0.083	0	0	0.000
7/12	1,047	9,021	0.352	62	349	0.335	95	252	0.256	376	580	0.237	0	0	0.000
7/13	40	9,061	0.353	10	359	0.344	0	252	0.256	29	609	0.249	0	0	0.000
7/14	232	9,293	0.362	9	368	0.353	6	258	0.262	29	638	0.261	0	0	0.000
7/15	493	9,786	0.382	25	393	0.377	16	274	0.278	102	740	0.302	0	0	0.000
7/16	926	10,712	0.418	10	403	0.386	18	292	0.296	179	919	0.376	0	0	0.000
7/17	1,724	12,436	0.485	37	440	0.422	39	331	0.336	147	1,066	0.436	0	0	0.000
7/18	1,259	13,695	0.534	70	510	0.489	61	392	0.398	87	1,153	0.471	0	0	0.000
7/19	956	14,651	0.571	33	543	0.521	85	477	0.484	51	1,204	0.492	0	0	0.000
7/20	678	15,329	0.598	50	593	0.569	60	537	0.545	65	1,269	0.519	4	4	0.001
7/21	832	16,161	0.630	53	646	0.619	41	578	0.587	92	1,361	0.556	1	5	0.001
7/22	723	16,884	0.658	100	746	0.715	39	617	0.626	115	1,476	0.603	3	8	0.001
7/23	504	17,388	0.678	19	765	0.733	49	666	0.676	114	1,590	0.650	4	12	0.002
7/24	765	18,153	0.708	24	789	0.756	38	704	0.715	113	1,703	0.696	7	19	0.003
7/25	382	18,535	0.723	12	801	0.768	11	715	0.726	59	1,762	0.720	4	23	0.004
7/26	448	18,983	0.740	5	806	0.773	17	732	0.743	59	1,821	0.744	6	29	0.005

-continued-

APPENDIX 2.—(Page 2 of 3)

	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
7/27	682	19,665	0.767	33	839	0.804	22	754	0.765	61	1,882	0.769	14	43	0.007
7/28	454	20,119	0.784	38	877	0.841	6	760	0.772	23	1,905	0.779	7	50	0.008
7/29	230	20,349	0.793	2	879	0.843	2	762	0.774	11	1,916	0.783	1	51	0.008
7/30	477	20,826	0.812	31	910	0.872	15	777	0.789	0	1,916	0.783	23	74	0.012
7/31	560	21,386	0.834	21	931	0.893	10	787	0.799	7	1,923	0.786	28	102	0.017
8/1	264	21,650	0.844	4	935	0.896	9	796	0.808	9	1,932	0.790	9	111	0.018
8/2	364	22,014	0.858	14	949	0.910	9	805	0.817	13	1,945	0.795	25	136	0.022
8/3	356	22,370	0.872	8	957	0.918	3	808	0.820	25	1,970	0.805	30	166	0.027
8/4	288	22,658	0.883	14	971	0.931	14	822	0.835	11	1,981	0.810	56	222	0.036
8/5	191	22,849	0.891	9	980	0.940	5	827	0.840	12	1,993	0.814	49	271	0.044
8/6	343	23,192	0.904	11	991	0.950	9	836	0.849	9	2,002	0.818	39	310	0.051
8/7	255	23,447	0.914	11	1,002	0.961	9	845	0.858	8	2,010	0.821	32	342	0.056
8/8	255	23,702	0.924	3	1,005	0.964	11	856	0.869	10	2,020	0.826	43	385	0.063
8/9	223	23,925	0.933	11	1,016	0.974	7	863	0.876	7	2,027	0.828	45	430	0.070
8/10	218	24,143	0.941	7	1,023	0.981	11	874	0.887	10	2,037	0.832	109	539	0.088
8/11	309	24,452	0.953	4	1,027	0.985	22	896	0.910	3	2,040	0.834	67	606	0.099
8/12	236	24,688	0.962	3	1,030	0.988	4	900	0.914	5	2,045	0.836	79	685	0.112
8/13	140	24,828	0.968	1	1,031	0.988	0	900	0.914	2	2,047	0.837	87	772	0.126
8/14 **	104	24,932	0.972	1	1,032	0.989	5	905	0.919	29	2,076	0.848	115	887	0.145
8/15 *	73	25,005	0.975	0	1,032	0.989	3	908	0.922	25	2,101	0.859	107	994	0.163
8/16 *	65	25,070	0.977	0	1,032	0.989	6	914	0.928	14	2,115	0.864	60	1,054	0.172
8/17 *	69	25,139	0.980	0	1,032	0.989	4	918	0.932	23	2,138	0.874	83	1,137	0.186
8/18 *	61	25,200	0.982	0	1,032	0.989	1	919	0.933	31	2,169	0.886	178	1,315	0.215
8/19 *	48	25,248	0.984	1	1,033	0.990	2	921	0.935	24	2,193	0.896	155	1,470	0.241
8/20 *	53	25,301	0.986	0	1,033	0.990	11	932	0.946	16	2,209	0.903	73	1,543	0.252
8/21 *	44	25,345	0.988	1	1,034	0.991	5	937	0.951	47	2,256	0.922	290	1,833	0.300
8/22 *	24	25,369	0.989	0	1,034	0.991	4	941	0.955	13	2,269	0.927	291	2,124	0.348
8/23 *	30	25,399	0.990	0	1,034	0.991	2	943	0.957	22	2,291	0.936	225	2,349	0.384
8/24 *	20	25,419	0.991	0	1,034	0.991	2	945	0.959	10	2,301	0.940	161	2,510	0.411
8/25 *	28	25,447	0.992	0	1,034	0.991	6	951	0.965	22	2,323	0.949	398	2,908	0.476
8/26 *	27	25,474	0.993	0	1,034	0.991	1	952	0.966	12	2,335	0.954	350	3,258	0.533
8/27 *	26	25,500	0.994	0	1,034	0.991	3	955	0.970	14	2,349	0.960	290	3,548	0.581
8/28 *	19	25,519	0.995	0	1,034	0.991	3	958	0.973	15	2,364	0.966	248	3,796	0.621

-continued-

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	Chum Salmon			Chinook Salmon			Sockeye Salmon			Pink Salmon			Coho Salmon		
	Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative		Daily	Cumulative	
	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion	Count	Count	Proportion
8/29	34	25,553	0.996	1	1,035	0.992	4	962	0.977	9	2,373	0.970	87	3,883	0.635
8/30	28	25,581	0.997	1	1,036	0.993	0	962	0.977	13	2,386	0.975	202	4,085	0.668
8/31	13	25,594	0.998	2	1,038	0.995	0	962	0.977	5	2,391	0.977	266	4,351	0.712
9/1	6	25,600	0.998	1	1,039	0.996	1	963	0.978	0	2,391	0.977	297	4,648	0.761
9/2	18	25,618	0.999	1	1,040	0.997	16	979	0.994	2	2,393	0.978	314	4,962	0.812
9/3	12	25,630	0.999	2	1,042	0.999	4	983	0.998	10	2,403	0.982	198	5,160	0.844
9/4	6	25,636	0.999	0	1,042	0.999	1	984	0.999	14	2,417	0.988	130	5,290	0.866
9/5	4	25,640	1.000	1	1,043	1.000	1	985	1.000	10	2,427	0.992	100	5,390	0.882
9/6 **	4	25,644	1.000	0	1,043	1.000	0	985	1.000	6	2,433	0.994	328	5,718	0.936
9/7 *	2	25,646	1.000	0	1,043	1.000	0	985	1.000	1	2,434	0.995	153	5,871	0.961
9/8 *	2	25,648	1.000	0	1,043	1.000	0	985	1.000	2	2,436	0.996	104	5,975	0.978
9/9 *	1	25,649	1.000	0	1,043	1.000	0	985	1.000	6	2,442	0.998	73	6,048	0.990
9/10 *	1	25,650	1.000	0	1,043	1.000	0	985	1.000	5	2,447	1.000	63	6,111	1.000

* No counts due to high water.
* *Partial counts due to high water.
Shaded area = Escapement estimate due to high water event
Boxed areas encompass quartiles (first, median, third).

APPENDIX 3.—Estimated age and sex composition of weekly chum salmon escapements through the Tuluksak River weir, Alaska, 2006, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group					
		2003	2002	2001	2000	1999	
		0.2	0.3	0.4	0.5	0.6	Total
Stratum 1 & 2:	06/25 - 07/08						
Sampling Dates:	07/03 - 07/05						
Male:	Number in Sample:	0	32	59	0	0	91
	Estimated % of Escapement:	0.0	21.2	39.1	0.0	0.0	60.3
	Estimated Escapement:	0	1,016	1,873	0	0	2,888
	Standard Error:	0.0	157.4	187.9	0.0	0.0	
Female:	Number in Sample:	0	14	46	0	0	60
	Estimated % of Escapement:	0.0	9.3	30.5	0.0	0.0	39.7
	Estimated Escapement:	0	444	1,460	0	0	1,905
	Standard Error:	0.0	111.7	177.3	0.0	0.0	
Total:	Number in Sample:	0	46	105	0	0	151
	Estimated % of Escapement:	0.0	30.5	69.5	0.0	0.0	100
	Estimated Escapement:	0	1,460	3,333	0	0	4,793
	Standard Error:	0.0	177.3	177.3	0.0	0.0	
Stratum 3:	07/09 - 07/15						
Sampling Dates:	07/09 and 07/10						
Male:	Number in Sample:	0	35	70	1	0	106
	Estimated % of Escapement:	0.0	19.6	39.1	0.6	0.0	59.2
	Estimated Escapement:	0	975	1,949	28	0	2,951
	Standard Error:	0.0	145.5	179	27.3	0.0	
Female:	Number in Sample:	4	31	38	0	0	73
	Estimated % of Escapement:	2.2	17.3	21.2	0.0	0.0	40.8
	Estimated Escapement:	111	863	1,058	0	0	2,033
	Standard Error:	54.2	138.8	150	0.0	0.0	
Total:	Number in Sample:	4	66	108	1	0	179
	Estimated % of Escapement:	2.2	36.9	60.3	0.6	0.0	100
	Estimated Escapement:	111	1,838	3,007	28	0	4,984
	Standard Error:	54.2	177	179.4	27.3	0.0	
Stratum 4:	07/16 - 07/22						
Sampling Dates:	07/16 and 07/17						
Male:	Number in Sample:	2	45	54	0	0	101
	Estimated % of Escapement:	1.1	23.9	28.7	0.0	0.0	53.7
	Estimated Escapement:	76	1,699	2,039	0	0	3,813
	Standard Error:	52.5	218.5	231.7	0.0	0.0	
Female:	Number in Sample:	1	47	39	0	0	87
	Estimated % of Escapement:	0.5	25	20.7	0.0	0.0	46.3
	Estimated Escapement:	38	1,775	1,472	0	0	3,285
	Standard Error:	37.3	221.8	207.7	0.0	0.0	
Total:	Number in Sample:	3	92	93	0	0	188
	Estimated % of Escapement:	1.6	48.9	49.5	0.0	0.0	100
	Estimated Escapement:	113	3,473	3,511	0	0	7,098
	Standard Error:	64.2	256	256.1	0.0	0.0	

APPENDIX 3.—(Page 2 of 3)

		Brood Year and Age Group					
		2002	2001	2000	1999	1998	
		0.2	0.3	0.4	0.5	0.6	Total
Stratum 5:	07/23 - 07/29						
Sampling Dates:	07/23						
Male:	Number in Sample:	0	44	45	0	0	89
	Estimated % of Escapement:	0.0	25.4	26	0.0	0.0	51.4
	Estimated Escapement:	0	881	901	0	0	1,783
	Standard Error:	0.0	112.1	113	0.0	0.0	
Female:	Number in Sample:	7	43	34	0	0	84
	Estimated % of Escapement:	4	24.9	19.7	0.0	0.0	48.6
	Estimated Escapement:	140	861	681	0	0	1,682
	Standard Error:	50.7	111.3	102.3	0.0	0.0	
Total:	Number in Sample:	7	87	79	0	0	173
	Estimated % of Escapement:	4	50.3	45.7	0.0	0.0	100
	Estimated Escapement:	140	1,743	1,582	0	0	3,465
	Standard Error:	50.7	128.8	128.3	0.0	0.0	
Stratum 6:	07/30 - 08/05						
Sampling Dates:	07/30						
Male:	Number in Sample:	2	60	27	0	0	89
	Estimated % of Escapement:	1.1	33.7	15.2	0.0	0.0	50
	Estimated Escapement:	28	843	379	0	0	1,250
	Standard Error:	19.1	85.6	65	0.0	0.0	
Female:	Number in Sample:	7	51	31	0	0	89
	Estimated % of Escapement:	3.9	28.7	17.4	0.0	0.0	50
	Estimated Escapement:	98	716	435	0	0	1,250
	Standard Error:	35.2	81.9	68.7	0.0	0.0	
Total:	Number in Sample:	9	111	58	0	0	178
	Estimated % of Escapement:	5.1	62.4	32.6	0.0	0.0	100
	Estimated Escapement:	126	1,559	815	0	0	2,500
	Standard Error:	39.7	87.7	84.9	0.0	0.0	
Stratum 7, 8, 9, 10, & 11:	08/06 - 09/10						
Sampling Dates:	08/06 - 09/05						
Male:	Number in Sample:	3	28	19	0	0	50
	Estimated % of Escapement:	1.6	15	10.2	0.0	0.0	26.7
	Estimated Escapement:	45	419	285	0	0	749
	Standard Error:	24.9	70.8	59.9	0.0	0.0	
Female:	Number in Sample:	13	81	43	0	0	137
	Estimated % of Escapement:	7	43.3	23	0.0	0.0	73.3
	Estimated Escapement:	195	1,213	644	0	0	2,052
	Standard Error:	50.5	98.3	83.5	0.0	0.0	
Total:	Number in Sample:	16	109	62	0	0	187
	Estimated % of Escapement:	8.6	58.3	33.2	0.0	0.0	100
	Estimated Escapement:	240	1,633	929	0	0	2,801
	Standard Error:	55.5	97.8	93.4	0.0	0.0	

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		Brood Year and Age Group					
		2002	2001	2000	1999	1998	
		0.2	0.3	0.4	0.5	0.6	Total
Strata 1 - 11:	06/25 - 09/10						
Sampling Dates:	07/03 - 09/05						
Male:	Number in Sample:	7	244	274	1	0	526
	% Males in Age Group:	1.1	43.4	55.3	0.2	0	100
	Estimated % of Escapement:	0.6	22.7	29	0.1	0	52.4
	Estimated Escapement:	149	5,833	7,426	28	0	13,435
	Standard Error:	61.2	344.4	376.3	27.3	0	
	Estimated Design Effects:	1.085	1.124	1.144	1.147	0	1.106
Female:	Number in Sample:	32	267	231	0	0	530
	% Females in Age Group:	4.8	48.1	47.1	0	0	100
	Estimated % of Escapement:	2.3	22.9	22.4	0	0	47.6
	Estimated Escapement:	582	5,873	5,751	0	0	12,206
	Standard Error:	103.4	331.2	345.3	0	0	
	Estimated Design Effects:	0.813	1.036	1.14	0	0	1.106
Total:	Number in Sample:	39	511	505	1	0	1,056
	Estimated % of Escapement:	2.9	45.7	51.4	0.1	0	100
	Estimated Escapement:	731	11,705	13,177	28	0	25,641 *
	Standard Error:	119.5	402.6	402	27.3	0	
	Estimated Design Effects:	0.868	1.088	1.077	1.147	0	

* Escapement estimates were used in the calculation of the total number of chum salmon. Estimates were made from 06/25 - 06/30, 08/14 - 08/28, and 09/6 - 09/10.

APPENDIX 4.—Estimated length at age composition of weekly chum salmon escapements through the Tuluksak River weir, Alaska, 2006.

		Brood Year and Age Group				
		2003	2002	2001	2000	1999
		0.2	0.3	0.4	0.5	0.6
Stratum 1 & 2:	06/25 - 07/08					
Sampling Dates:	07/03 - 07/05					
Male:	Mean Length		591	598		
	Std. Error		5	4		
	Range		540 - 640	525 - 670		
	Sample Size	0	32	59	0	0
Female:	Mean Length		550	571		
	Std. Error		6	4		
	Range		530 - 610	510 - 665		
	Sample Size	0	14	46	0	0
Stratum 3:	07/09 - 07/15					
Sampling Dates:	07/09 and 07/10					
Male:	Mean Length		560	569	575	
	Std. Error		7	3		
	Range		480 - 655	490 - 630	575 - 575	
	Sample Size	0	35	70	1	0
Female:	Mean Length	508	526	535		
	Std. Error	19	5	5		
	Range	470 - 560	465 - 575	465 - 590		
	Sample Size	4	31	38	0	0
Stratum 4:	07/16 - 07/22					
Sampling Dates:	07/16 and 07/17					
Male:	Mean Length	513	554	571		
	Std. Error	13	4	4		
	Range	500 - 525	505 - 630	505 - 650		
	Sample Size	2	45	54	0	0
Female:	Mean Length	490	529	541		
	Std. Error	0	5	5		
	Range	490 - 490	445 - 610	475 - 610		
	Sample Size	1	47	39	0	0
Stratum 5:	07/23 - 07/29					
Sampling Dates:	07/23					
Male:	Mean Length		571	583		
	Std. Error		5	6		
	Range		505 - 650	485 - 670		
	Sample Size	0	44	45	0	0
Female:	Mean Length	499	522	530		
	Std. Error	9	4	6		
	Range	460 - 540	470 - 585	470 - 590		
	Sample Size	7	43	34	0	0
Stratum 6:	07/30 - 08/05					
Sampling Dates:	07/30					
Male:	Mean Length	535	564	574		
	Std. Error	5	4	6		
	Range	530 - 540	475- 630	500 - 630		
	Sample Size	2	60	27	0	0
Female:	Mean Length	481	518	529		
	Std. Error	18	4	5		
	Range	400 - 530	420 - 570	440 - 580		
	Sample Size	7	51	31	0	0

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		Brood Year and Age Group				
		2003	2002	2001	2000	1999
		0.2	0.3	0.4	0.5	0.6
Stratum 7, 8, 9, 10, & 11:	08/06 - 09/10					
Sampling Dates:	08/06 - 09/05					
Male:	Mean Length	508	559	564		
	Std. Error	4	6	7		
	Range	500 - 515	490 - 620	515 - 635		
	Sample Size	3	28	19	0	0
Female:	Mean Length	484	506	526		
	Std. Error	4	3	4		
	Range	460 - 515	450 - 560	450 - 575		
	Sample Size	13	81	43	0	0
Strata 1 - 11:	06/25 - 09/10					
Sampling Dates:	07/03 - 09/05					
Male:	Mean Length	517	566	578	575	
	Std. Error	4	2	2	0	
	Range	500 - 540	475 - 655	485 - 670	575 - 575	
	Sample Size	7	244	274	1	0
Female:	Mean Length	490	520	540		
	Std. Error	5	2	2		
	Range	400 - 560	420 - 610	440 - 665		
	Sample Size	32	267	231	0	0

APPENDIX 5.—Estimated age and sex composition of weekly Chinook salmon escapements through the Tuluksak River weir, Alaska, 2006, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group					
		2003	2002	2001	2000	1999	
		1.1	1.2	1.3	1.4	1.5	Total
Stratum 1 & 2:	06/25 - 07/08						
Sampling Dates:	07/04 and 07/05						
Male:	Number in Sample:	0	17	4	2	0	23
	Estimated % of Escapement:	0.0	60.7	14.3	7.1	0.0	82.1
	Estimated Escapement:	0	126	30	15	0	171
	Standard Error:	0.0	18.2	13	9.6	0.0	
Female:	Number in Sample:	0	0	2	3	0	5
	Estimated % of Escapement:	0.0	0.0	7.1	10.7	0.0	17.9
	Estimated Escapement:	0	0	15	22	0	37
	Standard Error:	0.0	0.0	9.6	11.5	0.0	
Total:	Number in Sample:	0	17	6	5	0	28
	Estimated % of Escapement:	0.0	60.7	21.4	17.9	0.0	100
	Estimated Escapement:	0	126	45	37	0	208
	Standard Error:	0.0	18.2	15.3	14.3	0.0	
Stratum 3:	07/09 - 07/15						
Sampling Dates:	07/09 - 07/11, 7/13 - 7/14						
Male:	Number in Sample:	0	10	13	3	0	26
	Estimated % of Escapement:	0.0	31.3	40.6	9.4	0.0	81.3
	Estimated Escapement:	0	58	75	17	0	150
	Standard Error:	0.0	13.9	14.8	8.8	0.0	
Female:	Number in Sample:	0	0	2	3	1	6
	Estimated % of Escapement:	0.0	0.0	6.3	9.4	3.1	18.8
	Estimated Escapement:	0	0	12	17	6	35
	Standard Error:	0.0	0.0	7.3	8.8	5.2	
Total:	Number in Sample:	0	10	15	6	1	32
	Estimated % of Escapement:	0.0	31.3	46.9	18.8	3.1	100
	Estimated Escapement:	0	58	86	35	6	184
	Standard Error:	0.0	13.9	15	11.7	5.2	
Stratum 4:	07/16 - 07/22						
Sampling Dates:	07/16 - 07/20						
Male:	Number in Sample:	0	11	13	5	0	29
	Estimated % of Escapement:	0.0	26.2	31	11.9	0.0	69
	Estimated Escapement:	0	92	109	42	0	244
	Standard Error:	0.0	22.8	23.9	16.8	0.0	
Female:	Number in Sample:	0	0	2	11	0	13
	Estimated % of Escapement:	0.0	0.0	4.8	26.2	0.0	31
	Estimated Escapement:	0	0	17	92	0	109
	Standard Error:	0.0	0.0	11	22.8	0.0	
Total:	Number in Sample:	0	11	15	16	0	42
	Estimated % of Escapement:	0.0	26.2	35.7	38.1	0.0	100
	Estimated Escapement:	0	92	126	134	0	353
	Standard Error:	0.0	22.8	24.8	25.1	0.0	

APPENDIX 5.—(Page 2 of 2)

		Brood Year and Age Group					
		2002	2001	2000	1999	1998	
		1.1	1.2	1.3	1.4	1.5	Total
Stratum 5, 6, & 7:	07/23 - 08/12						
Sampling Dates:	07/24 - 08/09						
Male:	Number in Sample:	0	16	9	4	1	30
	Estimated % of Escapement:	0.0	34	19.1	8.5	2.1	63.8
	Estimated Escapement:	0	102	57	25	6	191
	Standard Error:	0.0	19.2	15.9	11.3	5.8	
Female:	Number in Sample:	0	1	4	10	2	17
	Estimated % of Escapement:	0.0	2.1	8.5	21.3	4.3	36.2
	Estimated Escapement:	0	6	25	64	13	108
	Standard Error:	0.0	5.8	11.3	16.6	8.2	
Total:	Number in Sample:	0	17	13	14	3	47
	Estimated % of Escapement:	0.0	36.2	27.7	29.8	6.4	100
	Estimated Escapement:	0	108	83	89	19	299
	Standard Error:	0.0	19.4	18.1	18.5	9.9	
Strata 8 - 11:	08/13 - 09/10						
No Samples Collected							
Strata 1 - 11:	06/25 - 09/10						
Sampling Dates:	07/04 - 08/09						
Male:	Number in Sample:	0	54	39	14	1	108
	% Males in Age Group:	0.0	50.1	35.9	13.2	0.8	100
	Estimated % of Escapement:	0.0	36.2	26	9.5	0.6	72.3
	Estimated Escapement:	0	378	271	100	6	755
	Standard Error:	0.0	37.5	34.8	24	5.8	
	Estimated Design Effects:	0.000	0.965	0.996	1.053	0.907	1.017
Female:	Number in Sample:	0	1	10	27	3	41
	% Females in Age Group:	0.0	2.2	23.7	67.7	6.4	100
	Estimated % of Escapement:	0.0	0.6	6.6	18.7	1.8	27.7
	Estimated Escapement:	0	6	69	196	18	289
	Standard Error:	0.0	5.8	19.8	31.6	9.7	
	Estimated Design Effects:	0.000	0.907	1.016	1.034	0.877	1.017
Total:	Number in Sample:	0	55	49	41	4	149
	Estimated % of Escapement:	0.0	36.8	32.5	28.3	2.4	100
	Estimated Escapement:	0	384	340	295	25	1,044 *
	Standard Error:	0.0	37.7	37.4	36.3	11.2	
	Estimated Design Effects:	0.000	0.965	1.007	1.021	0.872	

* Escapement estimates were used in the calculation of the total number of Chinook salmon. Estimates were made from 06/25 - 06/30, 08/14 - 08/28, and 09/6 - 09/10.

APPENDIX 6.—Estimated length at age composition of weekly Chinook salmon escapements through the Tuluksak River weir, Alaska, 2006.

		Brood Year and Age Group				
		2003	2002	2001	2000	1999
		1.1	1.2	1.3	1.4	1.5
Stratum 1 & 2:	06/25 - 07/08					
Sampling Dates:	07/04 and 07/05					
Male:	Mean Length		558	655	870	
	Std. Error		8	34		
	Range		500 - 620	590 - 705	870 - 870	
	Sample Size	0	17	3	1	0
Female:	Mean Length			760	830	
	Std. Error			20	64	
	Range			740 - 780	720 - 940	
	Sample Size	0	0	2	3	0
Stratum 3:	07/09 - 07/15					
Sampling Dates:	07/09 - 07/11, 7/13 - 7/14					
Male:	Mean Length		532	663	833	
	Std. Error		10	16	63	
	Range		470 - 590	570 - 790	710 - 920	
	Sample Size	0	10	13	3	0
Female:	Mean Length			750	828	950
	Std. Error			50	17	
	Range			700 - 800	800 - 860	950 - 950
	Sample Size	0	0	2	3	1
Stratum 4:	07/16 - 07/22					
Sampling Dates:	07/16 - 07/20					
Male:	Mean Length		556	673	809	
	Std. Error		12	16	45	
	Range		475 - 595	560 - 795	685 - 915	
	Sample Size	0	11	13	5	0
Female:	Mean Length			755	848	
	Std. Error			55	18	
	Range			700 - 810	750 - 925	
	Sample Size	0	0	2	11	0
Stratum 5, 6, & 7:	07/23 - 08/12					
Sampling Dates:	07/24 - 08/09					
Male:	Mean Length		553	731	846	890
	Std. Error		10	15	70	
	Range		485 - 635	690 - 810	655 - 980	890 - 890
	Sample Size	0	16	9	4	1
Female:	Mean Length		620	784	858	895
	Std. Error			24	21	5
	Range		620 - 620	730 - 840	700 - 930	890 - 900
	Sample Size	0	1	4	10	2
Strata 8 - 11:	08/13 - 09/10					
No Samples Collected						

APPENDIX 6.—(Page 2 of 2)

		Brood Year and Age Group				
		2003	2002	2001	2000	1999
		1.1	1.2	1.3	1.4	1.5
Strata 1 - 11:	06/25 - 09/10					
Sampling Dates:	07/04 - 08/09					
Male:	Mean Length		551	682	831	890
	Std. Error		5	9	29	
	Range		470- 635	560 - 810	655 - 980	890 - 890
	Sample Size	0	54	38	13	1
Female:	Mean Length		620	767	847	913
	Std. Error			18	13	5
	Range		620 - 620	700 - 840	700 - 940	890 - 950
	Sample Size	0	1	10	27	3

APPENDIX 7.—Estimated age and sex composition of weekly coho salmon escapements through the Tuluksak River weir, Alaska, 2006, and estimated design effects of the stratified sampling design.

		Brood Year and Age Group				
		2003	2002	2001	2000	
		1.1	2.1	3.1	4.1	Total
Strata 1 - 3:	06/25 - 07/15					
No Samples Collected						
Strata 4, 5, & 6:	07/16 - 08/05					
Sampling Dates:	07/20, 07/23 - 07/24, 07/26, 07/30					
Male:	Number in Sample:	2	5	1	0	8
	Estimated % of Escapement:	20	50	10	0.0	80
	Estimated Escapement:	54	136	27	0	217
	Standard Error:	35.5	44.3	26.6	0.0	
Female:	Number in Sample:	0	2	0	0	2
	Estimated % of Escapement:	0.0	20	0.0	0.0	20
	Estimated Escapement:	0	54	0	0	54
	Standard Error:	0.0	35.5	0.0	0.0	
Total:	Number in Sample:	2	7	1	0	10
	Estimated % of Escapement:	20	70	10	0.0	100
	Estimated Escapement:	54	190	27	0	271
	Standard Error:	35.5	40.6	26.6	0.0	
Stratum 7:	08/06 - 08/12					
Sampling Dates:	08/06 - 08/09					
Male:	Number in Sample:	2	10	0	0	12
	Estimated % of Escapement:	7.4	37	0.0	0.0	44.4
	Estimated Escapement:	31	153	0	0	184
	Standard Error:	20.6	37.9	0.0	0.0	
Female:	Number in Sample:	1	13	1	0	15
	Estimated % of Escapement:	3.7	48.1	3.7	0.0	55.6
	Estimated Escapement:	15	199	15	0	230
	Standard Error:	14.8	39.2	14.8	0.0	
Total:	Number in Sample:	3	23	1	0	27
	Estimated % of Escapement:	11.1	85.2	3.7	0.0	100
	Estimated Escapement:	46	353	15	0	414
	Standard Error:	24.7	27.9	14.8	0.0	
Strata 8, 9, 10, & 11:	08/13 - 09/10					
Sampling Dates:	8/19, 09/04, 09/05					
Male:	Number in Sample:	1	28	0	0	29
	Estimated % of Escapement:	1.5	43.1	0.0	0.0	44.6
	Estimated Escapement:	84	2,349	0	0	2,433
	Standard Error:	83.4	335.5	0.0	0.0	
Female:	Number in Sample:	4	31	1	0	36
	Estimated % of Escapement:	6.2	47.7	1.5	0.0	55.4
	Estimated Escapement:	336	2,601	84	0	3,020
	Standard Error:	162.8	338.4	83.4	0.0	
Total:	Number in Sample:	5	59	1	0	65
	Estimated % of Escapement:	7.7	90.8	1.5	0.0	100
	Estimated Escapement:	419	4,950	84	0	5,453
	Standard Error:	180.5	196.1	83.4	0.0	

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		Brood Year and Age Group				
		2002	2001	2000	1999	
		1.1	2.1	3.1	4.1	Total
Strata 1 - 11:	06/25 - 09/10					
Sampling Dates:	07/20 - 09/05					
Male:	Number in Sample:	5	43	1	0	49
	% Males in Age Group:	6	93.1	1	0.0	100
	Estimated % of Escapement:	2.7	43	0.4	0.0	46.2
	Estimated Escapement:	169	2,638	27	0	2,834
	Standard Error:	92.9	340.5	26.6	0.0	
	Estimated Design Effects:	0.882	1.285	0.448	0.000	1.27
Female:	Number in Sample:	5	46	2	0	53
	% Females in Age Group:	10.6	86.4	3	0.0	100
	Estimated % of Escapement:	5.7	46.5	1.6	0.0	53.8
	Estimated Escapement:	351	2,854	99	0	3,304
	Standard Error:	163.5	342.5	84.7	0.0	
	Estimated Design Effects:	1.346	1.281	1.226	0.000	1.27
Total:	Number in Sample:	10	89	3	0	102
	Estimated % of Escapement:	8.5	89.5	2.1	0	100
	Estimated Escapement:	520	5,492	126	0	6,138 *
	Standard Error:	185.6	202.2	88.8	0	
	Estimated Design Effects:	1.209	1.181	1.065	0	

* Escapement estimates were used in the calculation of the total number of coho salmon. Estimates were made from 06/25 - 06/30, 08/14 - 08/28, and 09/6 - 09/10.

APPENDIX 8.—Estimated length at age composition of weekly coho salmon escapements through the Tuluksak River weir, Alaska, 2006.

		Brood Year and Age Group		
		2003	2002	2001
		1.1	2.1	3.1
Strata 1 - 3:	06/25 - 07/15			
No Samples Collected				
Strata 4, 5, & 6:	07/16 - 08/05			
Sampling Dates:	07/20, 07/23 - 07/24, 07/26, 07/30			
Male:	Mean Length	543	508	545
	Std. Error	28	10	
	Range	515 - 570	490 - 540	545 - 545
	Sample Size	2	5	1
Female:	Mean Length		513	
	Std. Error		18	
	Range		495 - 530	
	Sample Size	0	2	0
Stratum 7:	08/06 - 08/12			
Sampling Dates:	08/06 - 08/09			
Male:	Mean Length	473	509	
	Std. Error	13	10	
	Range	460 - 485	460 - 555	
	Sample Size	2	10	0
Female:	Mean Length	470	510	520
	Std. Error		12	
	Range	470 - 470	420 - 555	520 - 520
	Sample Size	1	13	1
Strata 8, 9, 10, & 11:	08/13 - 09/10			
Sampling Dates:	8/19, 09/04, 09/05			
Male:	Mean Length	480	510	
	Std. Error		7	
	Range	480 - 480	440 - 590	
	Sample Size	1	28	0
Female:	Mean Length	519	519	575
	Std. Error	8	7	
	Range	500 - 535	430 - 580	575 - 575
	Sample Size	4	31	1
Strata 1 - 11:	06/25 - 09/10			
Sampling Dates:	07/20 - 09/05			
Male:	Mean Length	502	510	545
	Std. Error	15	5	
	Range	460 - 570	440- 590	545 - 545
	Sample Size	5	43	1
Female:	Mean Length	509	516	548
	Std. Error	8	6	
	Range	470 - 535	420 - 580	520 - 575
	Sample Size	5	46	2